(54) **Method of changing image information**

(57) The magnification ratio of image information carried on an original S is changed for reproduction at a desired magnification ratio. The size of the image information is reduced or enlarged to a prescribed size by an optical system 10, 16. Thereafter, the image information is photoelectrically converted by a light sensor 14. In an image processor 12, the photoel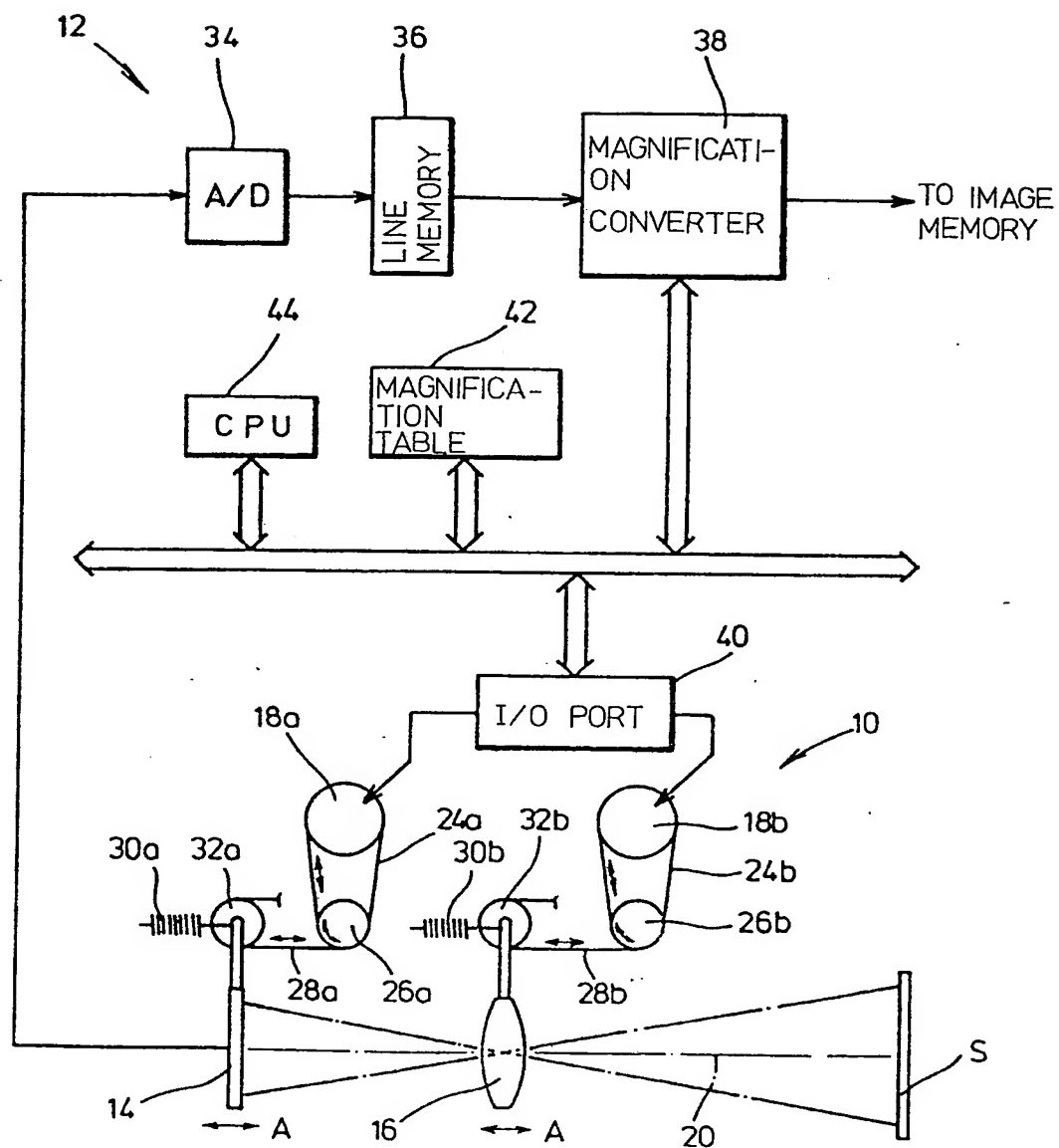ectrically converted image information is selectively picked up or data between adjacent items of the photoelectrically converted image information is determined by interpolation in magnification converter 38, thereby obtaining image information at a desired size.

FIG.1

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FIG.1

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FIG.2

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FIG.3

FIG.4

COMBINED MAGNIFICATION	OPTICAL MAGNIFICATION	ELECTRICAL MAGNIFICATION
100%	100%	100%
101	101	100
102	102	100
199	199	100
200	100	200
202	101	200
400	200	200
402	134	300
405	135	300
450	150	300
600	200	300

42

FIG.5

$D_{N+1} - D_N =$	$i = \phi$	$i = 1$	$i = 2$
255	ϕ	85	170
254	ϕ	84	169
253	ϕ	84	168
$q-p$	ϕ	$(q-p)/3$	$2(q-p)/3$
	ϕ	-84	-169
-255	ϕ	-85	-170

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FIG.6

SPECIFICATION

Method of changing image, magnification

5 BACKGROUND OF THE INVENTION
The present invention relates to a method of
changing image magnification, and more parti-
cularly to a method of enlarging or reducing
image information produced from a light sen-
10 sor after it has read an original image as mo-
dified in size by optical means, at a desired
magnification ratio with electric means, so that
an image which is magnified at a desired ratio
can be reproduced highly accurately and inex-
15 pensively.
In the field of printing plate-making, for
example, there has been employed an image
scanning recording and reproducing system for
electrically processing image information on an
20 original to produce an original film plate in
order to carry out the plate-making process
efficiently and improving the image quality.
The image scanning recording and reproduc-
ing system is basically composed of an image
25 reading device and an image reproducing de-
vice. In the image reading device, image infor-
mation on an original which is fed in an aux-
iliary scanning direction is scanned in a main
scanning direction by a light sensor, which
30 converts the image information to an electric
signal. Then, the photoelectrically converted
image information is subjected to gradation
correction, profile emphasis, and other image
processing in the image reproducing device
35 according to given plate-making conditions.
Thereafter, the image information is converted
to a light signal such as a laser beam signal
which is applied to a recording medium com-
prising a photosensitive material such as a
40 photographic film to record the image informa-
tion thereon. The image on the recording me-
dium is developed by an image developing de-
vice, and the recording medium will be used
as a film plate in a printing process.
45 It is preferable that the image information
carried on the original be reproduced at an
enlarged or reduced size by selecting a de-
sired magnification ratio. One method of
changing the magnification ratio of image in-
50 formation is to use a zoom lens in the optical
system for focusing the image information on
the light sensor and vary the magnification ra-
tio by operating the zoom lens.
A magnification ratio for image information
55 can be changed as desired by the zoom lens.
However, where image information is greatly
enlarged by the zoom lens, the image informa-
tion focused on the light sensor suffers from
various optical defects such as spherical aber-
60 ration, distortion, and the like, resulting in a
reduction in image accuracy. It would be tech-
nically difficult and highly expensive to pro-
duce a zoom lens having minimum aberrations
and capable of magnifying image information
65 in a wide magnification range.

It is also possible to employ a fixed-focus
lens, instead of a zoom lens, and to displace
the fixed-focus lens and the light sensor with
respect to an original for thereby changing the
70 magnification ratio.
With this method, however, the lens and
the light sensor must be displaced greatly in
order to greatly enlarge or reduce the original
image, and a wide space is necessary to ac-
75 commodate such a large displacement of the
lens and the light sensor. Where the magnifi-
cation of the original image is increased, opti-
cal defects or aberrations are produced to
lower the image accuracy, as with the zoom
80 lens.
An electrical process may be employed for
changing an image magnification ratio. For
example, image information photoelectrically
converted by a light sensor and stored in a
85 memory may be reproduced in a 1/2 size by
reading the stored information from every
other address of the memory. Likewise,
stored image information may be reproduced
in a reduced size at a magnification ratio of
90 1/3, 1/4, ... Conversely, an image may be
reproduced at a magnification ratio which is a
multiple of an integer by reading image infor-
mation several times from each address of the
memory.
95 It is however impossible to continuously
change the magnification ratio to obtain mag-
nification of × 1.3 or × 3.8, for example,
since available magnification ratios are mul-
tiples of an integer. An enlarged reproduced
100 image is not smooth and continuous because
it is reproduced by reading the stored informa-
tion several times from each address of the
memory.

105 SUMMARY OF THE INVENTION
The present invention provides a method of
changing the magnification ratio of an image
by reading, with a light sensor, an original
image produced at a desired size by optical
110 means, changing the magnification of the im-
age from the light sensor with electric means
to produce an image signal at a desired size,
so that an image which is magnified in a wide
magnification range can be reproduced highly
115 accurately and inexpensively.
According to the present invention there is
provided a method of changing the magnifica-
tion ratio of image information carried on an
original for reproduction at a desired magnifi-
120 cation ratio, the method comprising the steps
of reducing or enlarging the image information
to a prescribed size with optical means, there-
after, photoelectrically converting the image in-
formation with a light sensor, and selectively
125 picking up the photoelectrically converted im-
age information or determining data between
adjacent items of the photoelectrically con-
verted image information by interpolation,
thereby obtaining image information at a de-
130 sired size.

In the method of the present invention the
optical means may comprise a fixed-focus
lens, the light sensor and the fixed-focus lens
being displaceable with respect to the original
5 to change the magnification ratio of the image
information with respect to the light sensor.
   Alternatively the optical means may com-
prise a zoom lens for changing the magnifica-
tion ratio of the image information with re-
10 spect to the light sensor.
   Typically, magnification ratios established by
the optical means and magnification ratios
established by the electric means are stored in
combination in a magnification table. Data be-
15 tween the adjacent items of the photoelectri-
cally converted image information may be pro-
duced by using an interpolation table set up
according to enlarging magnification ratios
established by the electric means. The interpo-
20 lation table may be composed of interpolated
data produced for each of the magnification
ratios established by the electric means, the
interpolated data being selected according to
an enlarging magnification ratio established by
25 the electric means to interpolate the image in-
formation.
   According to another aspect of the inven-
tion there is provided an apparatus for provid-
ing image information at a desired magnifica-
30 tion ratio comprising means for supporting an
original image, an optical system for reducing
or enlarging the image information on said
original, a light sensor for photoelectrically
converting the image information output by
35 said optical system, and means for selectively
picking up the photoelectrically converted im-
age information or determining data between
adjacent items of the photoelectrically con-
verted information by interpolation to provide
40 image information relating to a desired magni-
fication ratio.
   The above features and advantages of the
present invention will become more apparent
from the following description when taken in
45 conjunction with the accompanying drawings
in which a preferred embodiment of the pre-
sent invention is shown by way of illustrative
example.

50 BRIEF DESCRIPTION OF THE DRAWINGS
   FIG. 1 is a schematic view, partly in block
form, of an image reading device which em-
ploys a method of changing the magnification
ratio of an image in accordance with the pre-
55 sent invention;
   FIG. 2 is a perspective view of the image
reading device shown in FIG. 1;
   FIG. 3 is a block diagram of a magnification
converting circuit shown in FIG. 1;
60   FIG. 4 is a magnification table produced in
the method of the invention;
   FIG. 5 shows an interpolation table pro-
duced in the method of the invention; and
   FIG. 6 is a diagram illustrating linear interpo-
65 lation effected in the method of the invention.

DESCRIPTION OF THE PREFERRED EMBODI-
MENT
   FIG. 1 shows an image reading device in
70 which a method of changing the magnification
ratio of an image according to the present
invention may be carried out. The image read-
ing device essentially comprises an image
reader 10 for optically reading image informa-
75 tion carried on an original S and an image
processor 12 for electrically processing the
image information read by the image reader
10.
   The image reader 10 includes a light sensor
80 14 in the form of a CCD for photoelectrically
converting light from the image information
carried on the original S, and a fixed-focus
lens 16 for focusing the image information at
a varied magnification ratio on the CCD 14.
85 The CCD 14 comprises a linear array of
photoelectric transducer elements, and is dis-
posed parallel to a main scanning direction in-
dicated by the arrow X (FIG. 2) for the original
S to scan the original S which is fed in an
90 auxiliary scanning direction indicated by the ar-
row Y.
   The CCD 14 is displaceable by a step motor
18a to move along an optical axis 20 of the
lens 16. More specifically, the step motor 18a
95 is operatively coupled to a drum 26a through
a belt 24a. A wire 28a has one end wound
around the drum 26a and an opposite end
fixed to the frame of the image reader 10 and
trained around a pulley 32a which is urged by
100 a spring 30a to move in a direction away
from the drum 26a, the pulley 32a being fixed
to the CCD 14.
   The lens 16 is displaceable by a step motor
18b in a direction along the optical axis 20.
105 Rotative drive power from the step motor 18b
is transmitted to the lens 16 by a mechanism
which is identical to the power transmitting
mechanism associated with the CCD 14.
Therefore, various parts of the power
110 transmitting mechanism associated with the
lens 16 are denoted by identical reference
numerals with a suffix b and will not be de-
scribed in detail. The magnification ratio of im-
age information focused on the CCD 14 is
115 optically variable by displacing the CCD 14
and the lens 16 along the optical axis 20 with
the step motors 18a, 18b.
   The image processor 12 comprises an A/D
converter 34 for converting the image infor-
120 mation which has been photoelectrically con-
verted by the CCD 14 to a digital signal, a
line memory 36 serving as a buffer for tempo-
rarily storing the digital image information from
the A/D converter 34, a magnification conver-
125 ter 38 for electrically processing the image
information to change its magnification, an I/O
port 40 for applying control signals to the
step motors 18a, 18b of the image reader 10,
and a magnification table 42 containing se-
130 lected combinations of magnification ratios.

These components of the image processor 12 are controlled by a CPU 44. The magnification table 42 contains magnification ratios that can be varied by the image reader 10 and magnifi-
5 cation ratios that can be varied by the magnification converter 38 in combination with desired magnification ratios for image information.

The magnification converter 38 is arranged
10 as shown in FIG. 3. The magnification converter 38 comprises a sequencer 46 for controlling an operation sequence of the magnification converter 38, a pair of latches 48, 50 for latching image data items fetched from the
15 line memory 36 based on an addressing command from the sequencer 46, a subtractor 52 for calculating the difference between the image data items latched in the latches 48, 50, an interpolation table 54 for producing interpo-
20 lated data based on the difference calculated by the subtractor 52, and an adder 56 for adding the image data latched in the latch 48 and the interpolated data and applying the sum data to an image memory (not shown).
25 The interpolation table 54 stores linear intepolation data items with respect to predicted values for the calculated data from the subtractor 52, in association with the magnfication ratios in the magnification converter 38.
30 A method of changing the magnification ratio of an image is carried out by the above arrangement as follows:

A magnification ratio for image information carried on the original S is expressed as the
35 product of a magnification ratio optically established in the image reader 10 and a magnification ratio electrically established by the magnification converter 38 of the image processor 12. Assuming that the image reader
40 10 has a range of magnification ratios of from 100 % to 200 % in increments of 1 % and the magnification converter 38 can establish magnification ratios of 100 %, 200 %, and 300 %, combined magnification ratios for a
45 reproduced image are as shown in FIG. 4. The combined magnifications range from 100 % to 600 % in increments of 1 through 3 %. These combinations of magnification ratios are stored as the magnification table 42 in a memory.
50 The combinations of the magnification ratios established in the image reader 10 and the magnification ratios established in the magnification covnerter 38 are selected such that the quality of reproduced images will be optimum.
55 A magnification ratio is converted by the magnification converter 38 based on the interpolation table 54. The interpolation table 54 is set up as illustrated in FIG. 5 assuming that the magnification ratio established by the mag-
60 nification converter 38 is 300 %. If image data is represented by 8 bits, the image data can be expressed by 256 level. Assuming that the Nth image data is indicated by D_N and the (N+1)th image data adjacent to the Nth image
65 data is indicated by D_{N+1}, the value of $(D_{N+1} -$

$D_N)$ can be expressed by 511 levels from −255 to 255. In order to obtain image data which is magnified at a magnification ratio of 300 %, the interval between the Nth image
70 data D_N and the (N+1)th image data D_{N+1} is divided into three segments and interporated data r_i (i = 0, 1, 2) with respect to the image data D_N at points of division i (i = 0, 1, 2) is obtained by linear interpolation. The deviation
75 of the interpolated data item r_0 from the image data is zero. Where the image data D_N is represented by p and the image data D_{N+1} is represented by q, the interpolated data items r_1, r_2 are expressed as follows:
80

$$r_1 = (q - p)/3ememem(1)$$
$$r_2 = 2 (q - p)/3ememem(2)$$

An interpolation table 54 with respect to the
85 magnification ratio of 300 % is prepared in this manner and stored in the memory. Likewise, interpolation tables 54 with respect to magnification ratios of 100 %, 200 % are prepared in the same manner. As the interpola-
90 tion table for the magnification ratio of 100 %, the interpolation table for the magnification table of 200 % or the interpolation table 54 for the magnification table of 300 % with i = 1 may be used.
95 After the magnification table 42 and the interpolation table 54 have been prepared, the original S is scanned to produce image data at a desired magnification ratio. By way of example, image information is magnified 150%
100 by the image reader 10 and then magnified 300 % by the magnification converter 38, so that image information is reproduced at a combined magnification of 450 %.

First, desired magnification data 450 % is
105 applied from an input device (not shown) to the image processor 12. The image processor 12 then selects a magnification ratio of 150 % optically established by the image reader 10 and a magnification ratio of 300 % electri-
110 cally established by the magnification converter 38, from the magnification table 42 (FIG. 4). Then, the CPU 44 applies a control signal corresponding to the magnification ratio of 150 % established by the image reader 10 to
115 the step motors 18a, 18b through the I/O port 40. In response to the applied control signal, the step motors 18a, 18b rotate the drums 26a, 26b through the respective belts 24a, 24b to displace the respective wires
120 28a, 28b in directions of the arrows. Since the wires 28a, 28b are trained around the respective pulleys 32a, 32b, the CCD 14 and the lens 16 are displaced by the pulleys 32a, 32b in the directions of the arrows A. As a
125 result, the conjugate lengths bewteen the CCD 14 and the lens 16 and between the lens 16 and the original S are varied to focus the image information carried by the original S onto the CCD 14 at the magnification ratio of 150
130 %.

The image information which is photoelectrically converted by the CCD 14 is converted by the A/D converter 34 to a digital signal which is stored in the line memory 36.

5 The sequencer 46 of the magnification converter 38 is supplied with a clock signal, a synchronizing signal, and a magnification signal in timed relation to the image scanning operation effected by the CCD 14. As the magnifi-
10 cation signal, a magnification signal indicative of 300 % established by the magnification table 42 shown in FIG. 4 is applied. The sequencer 46 then specifies data addresses of the line memory 36 based on the clock signal.
15 The line memory 36 thus addressed by the sequencer 46 supplies Nth image data D_N to the latch 48 and also supplies (N+1)th image data D_{N+1}. The image data items D_N, D_{N+1} latched by the respective latches 48, 50 are
20 then supplied to the subtractor 52 which then calculates their difference according to $(D_{N+1} - D_N)$.

A prescribed interpolation table 54 is selected on the basis of the magnification signal
25 which is established by the magnification table 42 for the magnification converter 38. At this time, the interpolation table 54 with respect to 300 % as shown in FIG. 5 is selected. In the interpolation table 54, levels corresponding
30 to the difference $(D_{N+1} - D_N)$ calculated by the subtractor 52 are selected, and intepolated data items r, (i = 0, 1, 2) at these levels are successively indicated by the sequencer 46 and applied to the adder 56.
35 The adder 56 adds the image data D_N from the latch 48 and the interpolated data items r, (i = 0, 1, 2). As a result, two new image data items are produced between the image data D_N, D_{N+1}.
40 In the above manner, the image information of the original S is enlarged 150 % by the lens 16 of the image reader 10, and thereafter enlarged 300 % by the magnification converter 38. As a consequence, the image informa-
45 tion is enlarged 450 % and stored in the image memory. The enlarged image information is then supplied to an image reproducing device in which is is reproduced highly accurately without optical defects or aberrations.
50 While in the above embodiment image information is obtained at the magnification ratio of 450 %, image information may be obtained at other magnification ratios that can be established by the magnification table 42. The mag-
55 nification table 42 is shown as having combined magnification ratios of 100 % or larger. However, it is easy to obtain image information at a combined magnification ranging from 50 % to 100 %. For example, in order to
60 have a combined magnification ratio of 50 %, image information may be reduced 50 % in size by the optical means, or the magnification ratio according to the optical means may be selected to be 100 %, and every other image
65 data may be selected by the electric means

for storage in the image memory.

With the arrangement of the present invention, as described above, an original image is reduced or enlarged in size by optical means,
70 and read by a photoelectric transducer device, and then magnified image information from the photoelectric transducer device is selectively picked up or data between image information items are interpolated by electric means, so
75 that image information can be obtained at a desired magnification ratio. Accordingly, image information can be reduced or enlarged highly accurately without optical defects or aberrations in a wide range of magnification ratios.
80 The arrangement required to perform the above method is inexpensive since an expensive zoom lens is not employed as optical means to change magnification ratios. When image information is enlarged, image data be-
85 tween adjacent pixels of the original image is produced by linear interpolation. Therefore, a smooth enlarged image of continuous gradation can be reproduced at a large magnification ratio.
90 The drive system or mechanism in the image reader 10 may be simplified by employing a relatively inexpensive zoom lens in place of the fixed-focus lens 16.

Although a certain preferred embodiment
95 has been shown and described, it should be understood that many changes and modifications may be made therein without departing from the scope of the appended claims.

100 CLAIMS
1. A method of changing the magnification ratio of image information carried on an original for reproduction at a desired magnification ratio, said method comprising the steps of:
105 reducing or enlarging said image information to a prescribed size with optical means;
thereafter, photoelectrically converting said image information with a light sensor; and
selectively picking up the photoelectrically
110 converted image information or determining data between adjacent items of the photoelectrically converted image information by interpolation, thereby obtaining image information at a desired size.
115 2. A method according to claim 1, wherein said optical means comprises a fixed-focus lens, said light sensor and said fixed-focus lens being displaceable with respect to the original to change the magnification ratio of
120 the image information with respect to said light sensor.
3. A method according to claim 1, wherein said optical means comprises a zoom lens for changing the magnification ratio of the image
125 information with respect to said light sensor.
4. A method according to claim 1, wherein magnification ratios established by said optical means and magnification ratios established by said electric means are stored in combination
130 in a magnification table.

5. A method according to claim 1, wherein the data between the adjacent items of the photoelectrically converted image information is produced by using an interpolation table set
5 up according to enlarging magnification ratios established by said electric means.

6. A method according to claim 5, wherein said interpolation table is composed of interpolated data produced for each of the magnifi-
10 cation ratios established by said electric means, said interpolated data being selected according to an enlarging magnification ratio established by said electric means to interpolate the image information.
15 7. A method accoridng to claim 1 substantially as described herein with reference to the accompanying drawings.

8. A method of producing a printing plate wherein image information obtained by a
20 method according to any one of claims 1 to 7 is converted to a light signal which is applied to a light sensitive recording medium which is developed to produce an image derived from said image information.
25 9. Apparatus for providing image information at a desired magnification ratio comprising means for supporting an original image, an optical system for reducing or enlarging the image information on said original, a light sensor
30 for photoelectrically converting the image information output by said optical system, and means for selectively picking up the photoelectrically converted image information or determining data between adjacent items of the
35 photoelectrically converted information by interpolation to provide image information relating to a desired magnification ratio.